

Claims

1. A DME fuel supply device for a diesel engine having:
 - a feed pump for pressurizing DME fuel in a fuel tank to a specified pressure and delivering it into a feed pipe;
 - an injection pump for delivering DME fuel in a fuel gallery into which the DME fuel delivered via the feed pipe flows in a specified amount to an injection pipe communicated with a fuel injection nozzle of the diesel engine at specified timing;
 - an overflow fuel pipe for returning DME fuel overflowed from the fuel injection nozzle and DME fuel overflowed from the injection pump to the fuel tank; and
 - residual fuel retrieving means for retrieving DME fuel remaining in the fuel gallery and the overflow fuel pipe after stopping the diesel engine into the fuel tank;
- the DME fuel supply device comprising:
 - a vapor-phase pressure delivery pipe connecting an inlet of the fuel gallery to which the feed pipe is connected and a vapor phase in the fuel tank; and
 - a vapor-phase pressure delivery pipe switching solenoid valve for opening and closing the vapor-phase pressure delivery pipe.
2. The DME fuel supply device for a diesel engine according to Claim 1, wherein the vapor-phase pressure delivery pipe has a small-diameter portion where the inside diameter is partially reduced.
3. The DME fuel supply device for a diesel engine according to claim 1 or 2, wherein the residual fuel retrieving means has an aspirator which is disposed between the feed pipe and the overflow fuel pipe and which returns DME fuel delivered from the feed pump to the fuel tank so that the DME fuel remaining in the fuel gallery and the overflow fuel pipe can be drown by the returning DME fuel and retrieved into the fuel tank.
4. The DME fuel supply device for a diesel engine according to Claim 3,

wherein the residual fuel retrieving means has a first solenoid valve for communicating a delivery port of the feed pipe with either an inlet to a circulation passage of the aspirator or an inlet to the fuel gallery; a second solenoid valve for opening and closing the communication of a suction port of the aspirator with the fuel gallery and the overflow fuel pipe; and a DME fuel retrieving control section for performing control to switch the first solenoid valve to communicate it with the inlet of the aspirator and open the second solenoid valve to form a passage for returning the DME fuel delivered from the feed pump to the fuel tank and open the vapor-phase pressure delivery pipe switching solenoid valve and to close only the vapor-phase pressure delivery pipe switching solenoid valve after a lapse of a predetermined period of time.

5. The DME fuel supply device for a diesel engine according to Claim 1 or 2, wherein the injection pump has an injection pump element having a delivery valve which can be opened and closed by up-and-down movement of a plunger in engagement with a camshaft rotated by rotation transmitted from a driving shaft of the diesel engine and which can deliver the DME fuel in the fuel gallery into which the DME fuel delivered from the fuel tank via the feed pipe flows in a specified amount to an injection pipe in communication with a fuel injection nozzle of a diesel engine at specified timing; and injection state switching means for switching the injection pump element between an injection state in which the delivery valve is opened and closed by a cam of the camshaft and a non-injection state in which the delivery valve is not opened and closed even when the plunger is moved up and down by the cam, and wherein the injection pump element allows communication between the injection pipe and the fuel gallery even if the delivery valve is closed only in the non-injection state.

6. The DME fuel supply device for a diesel engine according to Claim 5, wherein the plunger of the injection pump element has a generally cylindrical shape and is rotated circumferentially in a plunger barrel by the injection

state switching means, and the injection amount of the DME fuel is changed according to the rotational position of the plunger, and wherein the injection pump element is brought into the non-injection state and a purge passageway for communicating the injection pipe and the fuel gallery is formed when the plunger is rotated to such a rotational position that the injection amount is zero.

7. The DME fuel supply device for a diesel engine according to Claim 6, wherein the injection pump element has a delivery valve holder having a delivery valve insertion hole communicated with the injection pipe; a delivery valve received in the delivery valve insertion hole for reciprocating movement; a delivery valve seat disposed integrally with the delivery valve holder and having a valve seat part for shutting off the communication between the injection pipe and the fuel gallery to establish a valve-closed state when a valve part of the delivery valve comes into contact with it; a delivery spring for urging the delivery valve toward the delivery valve seat; a plunger barrel disposed integrally with the delivery valve seat and having a compression chamber communicated with the delivery valve seat; a plunger received in the compression chamber for reciprocating movement and having an end opposed to the delivery valve; and a plunger spring for urging the plunger toward the cam,

wherein, when the injection pump element is in the injection state, the plunger is pushed up from the valve-closed state by the cam to shut off the communication between the compression chamber and the fuel gallery, the DME fuel in the compression chamber pushes up to open the delivery valve and brings the delivery valve into an open state, the DME fuel in the compression chamber is delivered under pressure to the injection pipe through the delivery valve in the open state, the compression chamber and the fuel gallery are communicated with each other again via a notch formed in an outer peripheral surface of the plunger, and the liquid pressure in the compression chamber is decreased and the delivery valve is closed by the urging force of the delivery spring, and

wherein, when the injection pump element is in the non-injection state, the plunger is rotated circumferentially by the injection state switching means to such a rotational position that a purge groove formed in an outer peripheral surface of the plunger and a purge port formed in an inner peripheral surface of the plunger barrel are communicated with each other, and the injection pipe and the fuel gallery are communicated with each other via the purge port, the purge groove, and a purge passage formed in the delivery valve seat for communicating the injection pipe and the purge port.

8. The DME fuel supply device for a diesel engine according to Claim 5, wherein the injection pump has a cam chamber in which the camshaft is placed and lubricating oil is reserved and which has an exclusive lubricating system separated from a lubricating system of the diesel engine, and wherein an oil separator for separating DME fuel from lubricating oil containing the DME fuel and a compressor driven by a cam of the camshaft for pressurizing the separated DME fuel and delivering it to the fuel tank are disposed in the cam chamber.

9. A DME fuel supply device for a diesel engine having an injection pump for delivering DME fuel supplied from a fuel tank via a feed pipe in a specified amount to an injection pipe in communication with a fuel injection nozzle of the diesel engine at specified timing, the DME fuel supply device comprising:
means for cooling the injection pipe.

10. The DME fuel supply device for a diesel engine according to Claim 9, wherein the injection pipe has an injection fuel passage through which DME fuel delivered from the injection pump to the fuel injection nozzle flows and a coolant passage through which coolant for cooling the DME fuel flowing through the injection fuel passage flows, and has a double pipe structure in which the coolant flows along the outer peripheral surface of the injection fuel passage.

11. The DME fuel supply device for a diesel engine according to Claim 10, wherein a coating of a heat insulating material is applied on the outer peripheral surface of the injection pipe.

12. The DME fuel supply device for a diesel engine according to Claim 10 or 11, further comprising an overflow fuel pipe for returning the DME fuel overflowed from the fuel injection pump to the fuel tank; and a nozzle return pipe for delivering DME fuel overflowed from the fuel injection nozzle to the overflow fuel pipe, wherein the DME fuel flows from the feed pipe to the nozzle return pipe through the coolant passage as the coolant.

13. The DME fuel supply device for a diesel engine according to Claim 12, further comprising a overflow valve disposed in the overflow pipe for maintaining the pressure of the DME fuel in the fuel gallery in the injection pump and regulating the overflowed DME fuel to flow only in the direction of being returned to the fuel tank, wherein the nozzle return pipe is connected downstream of the overflow valve.

14. The DME fuel supply device for a diesel engine according to Claim 13, further comprising a check valve disposed in the nozzle return pipe for regulating the overflowed DME fuel from the fuel injection nozzle to flow only in the direction of being returned to the fuel tank.

15. The DME fuel supply device for a diesel engine according to Claim 13, further comprising residual fuel retrieving means for retrieving the DME fuel remaining in the fuel gallery, the nozzle return pipe and the overflow fuel pipe after stopping the diesel engine into the fuel tank; and a coolant passage retrieving pipe for connecting the upstream side of the overflow valve and the nozzle return pipe when the residual fuel retrieving means retrieves the DME fuel in the coolant passage.

16. The DME fuel supply device for a diesel engine according to Claim 15,

further comprising an oil separator for separating DME fuel contained in lubricating oil in the cam chamber in the injection pump having an exclusive lubricating system which is separated from the lubricating system of the diesel engine; a compressor for pressurizing the DME fuel separated by the oil separator and delivering it to the fuel tank; a low-pressure tank disposed between the oil separator and the compressor; a purge pipe for communicating the low-pressure tank and the overflow fuel pipe; and a purge pipe switching solenoid valve for opening and closing the purge pipe.

17. The DME fuel supply device for a diesel engine according to Claim 16, further comprising a check valve disposed between the oil separator and the low-pressure tank for maintaining the pressure on the oil separator side and preventing DME fuel from flowing in reverse direction from the low-pressure tank to the oil separator.

18. The DME fuel supply device for a diesel engine according to Claim 16, further comprising DME fuel retrieving control section for performing control to retrieve the DME fuel remaining in the fuel gallery, the nozzle return pipe and the overflow fuel pipe into the fuel tank with the residual fuel retrieving means for a predetermined period of time and then open the purge pipe switching solenoid valve to retrieve the DME fuel which was unable to be retrieved by the residual fuel retrieving means using a negative pressure in the low-pressure tank after stopping the diesel engine.

19. The DME fuel supply device for a diesel engine according to Claim 16, further comprising a supply fuel cooling unit for cooling DME fuel flowing through the feed pipe with a cooling cycle using the DME fuel as coolant; temperature detecting means for detecting the temperature of the DME fuel in the injection pump; and a supply fuel temperature control section for controlling the supply fuel cooling unit to control the temperature of the DME fuel flowing through the feed pipe so that the temperature of DME fuel to be delivered to the injection pipe can be constant based on the temperature of the

DME fuel in the injection pump detected by the temperature detecting means.

20. The DME fuel supply device for a diesel engine according to Claim 19, wherein the supply fuel cooling unit has a fuel cooler using DME fuel as coolant; a coolant supply pipe for supplying DME fuel as the coolant from the fuel tank to the fuel cooler; and a coolant supply pipe switching solenoid valve for opening and closing the coolant supply pipe, wherein the fuel cooler evaporates DME fuel flowing through the coolant supply pipe and cools DME fuel flowing through the feed pipe using the heat of vaporization of the DME fuel, and wherein the supply fuel temperature control section control the temperature of the DME fuel flowing through the feed pipe by opening and closing the coolant supply pipe switching solenoid valve.

21. The DME fuel supply device for a diesel engine according to Claim 20, wherein the DME fuel supplied from the fuel tank to the fuel cooler and evaporated therein is delivered to the compressor.

22. The DME fuel supply device for a diesel engine according to any one of Claims 9 to 11, wherein the DME fuel delivered from the injection pump is supplied to a common rail and delivered to the fuel injection nozzle from the common rail.

23. A DME fuel supply device for a diesel engine having an injection pump for delivering DME fuel supplied from a fuel tank via a feed pipe in a specified amount to an injection pipe in communication with a fuel injection nozzle of the diesel engine at specified timing,

the DME fuel supply device comprising:

a supply fuel cooling unit for cooling DME fuel flowing through the feed pipe with a cooling cycle using DME fuel as coolant;

temperature detecting means for detecting the temperature of DME fuel in the injection pump; and

a supply fuel temperature control section for controlling the supply fuel

cooling unit to control the temperature of DME fuel flowing through the feed pipe so that the temperature of DME fuel to be delivered to the injection pipe can be constant based on the temperature of DME fuel in the injection pump detected by the temperature detecting means.

24. The DME fuel supply device for a diesel engine according to Claim 23, wherein the supply fuel cooling unit has a fuel cooler using DME fuel as coolant; a coolant supply pipe for supplying the DME fuel as the coolant from the fuel tank to the fuel cooler; and a coolant supply pipe switching solenoid valve for opening and closing the coolant supply pipe,

wherein the fuel cooler evaporates the DME fuel flowing through the coolant supply pipe and cools the DME fuel flowing through the feed pipe using the heat of vaporization of the DME fuel, and wherein the supply fuel temperature control section control the temperature of DME fuel flowing through the feed pipe by opening and closing the coolant supply pipe switching solenoid valve.

25. The DME fuel supply device for a diesel engine according to Claim 24, further comprising an oil separator for separating DME fuel contained in lubricating oil in the cam chamber in the injection pump having an exclusive lubricating system which is separated from the lubricating system of the diesel engine; and a compressor for pressurizing the DME fuel separated by the oil separator and delivering it to the fuel tank,

wherein the DME fuel supplied from the fuel tank to the fuel cooler and evaporated therein is delivered to the compressor.

26. The DME fuel supply device for a diesel engine according to any one of Claims 23 to 25, wherein the fuel temperature detecting means detects the temperature of DME fuel in the fuel gallery.

27. The DME fuel supply device for a diesel engine according to any one of Claims 23 to 25, further comprising means for cooling the injection pipe.

28. The DME fuel supply device for a diesel engine according to Claim 27, wherein the injection pipe has an injection fuel passage through which DME fuel delivered from the injection pump to the fuel injection nozzle flows and a coolant passage through which coolant for cooling the DME fuel flowing through the injection fuel passage flows, and has a double pipe structure in which the coolant flows along the outer peripheral surface of the injection fuel passage.

29. The DME fuel supply device for a diesel engine according to Claim 28, wherein a coating of a heat insulating material is applied on the outer peripheral surface of the injection pipe.

30. The DME fuel supply device for a diesel engine according to Claim 28, further comprising an overflow fuel pipe for returning DME fuel overflowed from the fuel injection pump to the fuel tank; and a nozzle return pipe for delivering the DME fuel overflowed from the fuel injection nozzle to the overflow fuel pipe, wherein the DME fuel flows from the feed pipe to the nozzle return pipe through the coolant passage as the coolant.

31. The DME fuel supply device for a diesel engine according to any one of Claims 23 to 25, wherein the DME fuel delivered from the injection pipe is supplied to a common rail and delivered to the fuel injection nozzle from the common rail.

32. A DME fuel supply device for a diesel engine having:

an injection pump for delivering DME fuel supplied from a fuel tank via a feed pipe in a specified amount to an injection pipe in communication with a fuel injection nozzle of a diesel engine at specified timing;

an overflow fuel pipe for returning the DME fuel overflowed from the fuel injection pump to the fuel tank;

a nozzle return pipe for delivering the DME fuel overflowed from the fuel

injection nozzle to the overflow fuel pipe; and

residual fuel retrieving means for retrieving the DME fuel remaining in a fuel gallery, the nozzle return pipe and the overflow fuel pipe after stopping the diesel engine into the fuel tank;

the DME fuel supply device comprising:

an oil separator for separating the DME fuel contained in lubricating oil in the cam chamber in the injection pump having an exclusive lubricating system which is separated from the lubricating system of the diesel engine;

a compressor for pressurizing the DME fuel separated by the oil separator and delivering it to the fuel tank;

a low-pressure tank disposed between the oil separator and the compressor;

a purge pipe for communicating the low-pressure tank and the overflow fuel pipe; and

a purge pipe switching solenoid valve for opening and closing the purge pipe.

33. The DME fuel supply device for a diesel engine according to Claim 32, further comprising a check valve disposed between the oil separator and the low-pressure tank for maintaining the pressure on the oil separator side and preventing DME fuel from flowing in reverse direction from the low-pressure tank to the oil separator.

34. A DME fuel supply device for a diesel engine having:

an injection pump for delivering DME fuel supplied from a fuel tank via a feed pipe in a specified amount to an injection pipe in communication with a fuel injection nozzle of a diesel engine at specified timing;

an overflow fuel pipe for returning the DME fuel overflowed from the fuel injection pump to the fuel tank;

a nozzle return pipe for delivering DME fuel overflowed from the fuel injection nozzle to the overflow fuel pipe; and

residual fuel retrieving means for retrieving the DME fuel remaining in the fuel gallery, the nozzle return pipe and the overflow fuel pipe after stopping

the diesel engine into the fuel tank;

the DME fuel supply device comprising:

an oil separator for separating DME fuel contained in lubricating oil in the cam chamber in the injection pump having an exclusive lubricating system which is separated from the lubricating system of the diesel engine;

a compressor for pressurizing the DME fuel separated by the oil separator and delivering it to the fuel tank;

a low-pressure tank connected to a suction port of the compressor;

a purge pipe for communicating the low-pressure tank and the overflow fuel pipe; and

a purge pipe switching solenoid valve for opening and closing the purge pipe.

35. The DME fuel supply device for a diesel engine according to Claim 34, further comprising a check valve disposed between the compressor and the low-pressure tank for maintaining the pressure in the low-pressure tank.

36. The DME fuel supply device for a diesel engine according to any one of Claims 32 to 35, further comprising DME fuel retrieving control section for performing control to retrieve DME fuel remaining in the fuel gallery, the nozzle return pipe and the overflow fuel pipe into the fuel tank with the residual fuel retrieving means for a predetermined period of time and then open the purge pipe switching solenoid valve to retrieve the DME fuel which was unable to be retrieved by the residual fuel retrieving means using a negative pressure in the low-pressure tank after stopping the diesel engine.

37. The DME fuel supply device for a diesel engine according to any one of Claims 32 to 35, further comprising a vapor-phase pressure delivery pipe connecting an inlet of the fuel gallery to which the feed pipe is connected and a vapor phase in the fuel tank; and a vapor-phase pressure delivery pipe switching solenoid valve for opening and closing the vapor-phase pressure delivery pipe.

38. The DME fuel supply device for a diesel engine according to Claim 37, wherein the vapor-phase pressure delivery pipe has a small-diameter portion where the inside diameter is partially reduced.

39. The DME fuel supply device for a diesel engine according to Claim 38, further comprising a feed pump for pressurizing DME fuel in a fuel tank to a specified pressure and delivering it into a feed pipe, wherein the residual fuel retrieving means has an aspirator which is disposed between the feed pipe and the overflow fuel pipe and which returns the DME fuel delivered from the feed pump to the fuel tank so that the DME fuel remaining in the fuel gallery and the overflow fuel pipe can be drawn by the returning DME fuel and retrieved into the fuel tank.

40. The DME fuel supply device for a diesel engine according to claim 39, wherein the residual fuel retrieving means has a first solenoid valve for communicating a delivery port of the feed pipe with either an inlet to a circulation passage of the aspirator or an inlet to the fuel gallery, and a second solenoid valve for opening and closing the communication of a suction port of the aspirator with the fuel gallery and the overflow fuel pipe, wherein the DME fuel retrieving control section performs control to switch the first solenoid valve to communicate it with the inlet of the aspirator and open the second solenoid valve to form a passage for returning the DME fuel delivered from the feed pump to the fuel tank and open the vapor-phase pressure delivery pipe switching solenoid valve and to close only the vapor-phase pressure delivery pipe switching solenoid valve a lapse of a predetermined period of time for a predetermined period of time after stopping the diesel engine.

41. The DME fuel supply device for a diesel engine according to Claim 40, wherein the DME fuel retrieving control section has means for opening the purge pipe switching solenoid valve after the second solenoid valve has been

closed.

42. The DME fuel supply device for a diesel engine according to any one of Claims 32 to 35, further comprising a supply fuel cooling unit for cooling DME fuel flowing through the feed pipe with a cooling cycle using the DME fuel as coolant; temperature detecting means for detecting the temperature of the DME fuel in the injection pump; and a supply fuel temperature control section for controlling the supply fuel cooling unit to control the temperature of the DME fuel flowing through the feed pipe so that the temperature of the DME fuel to be delivered to the injection pipe can be constant based on the temperature of the DME fuel in the injection pump detected by the temperature detecting means.

43. The DME fuel supply device for a diesel engine according to Claim 42, wherein the supply fuel cooling unit has a fuel cooler using DME fuel as coolant; a coolant supply pipe for supplying the DME fuel as the coolant from the fuel tank to the fuel cooler; and a coolant supply pipe switching solenoid valve for opening and closing the coolant supply pipe, wherein the fuel cooler evaporates the DME fuel flowing through the coolant supply pipe and cools the DME fuel flowing through the feed pipe using the heat of vaporization of the DME fuel, and wherein the supply fuel temperature control section control the temperature of the DME fuel flowing through the feed pipe by opening and closing the coolant supply pipe switching solenoid valve.

44. The DME fuel supply device for a diesel engine according to Claim 43, wherein the DME fuel supplied from the fuel tank to the fuel cooler and evaporated therein is delivered to the compressor.

45. The DME fuel supply device for a diesel engine according to any one of Claims 32 to 35, wherein the DME fuel delivered from the injection pipe is supplied to a common rail and delivered to the fuel injection nozzle from the common rail.